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DEPARTMENT OF AGRICULTURE
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THE
HESSIAN-FLY AND THE WESTERN
WHEAT-STEM SAW-FLY

IN
MANITOBA, SASKATCHEWAN AND ALBERTA

By
NORMAN CRIDDLE,
Field Officer.

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OTTAWA, March 25, 1915.

To the Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit for your approval Entomological Bulletin No. 11, entitled "The Hessian-fly and the Western Wheat-stem Saw-fly in Manitoba, Saskatchewan, and Alberta," which has been written by Mr. Norman Criddle, Field Officer in charge of the Entomological Laboratory at Treesbank, Man.

The Hessian-fly is well known to farmers as a serious pest of cereal crops, and while its depredations in the prairie provinces have not, as yet, attained the extensive proportions experienced in other regions of Canada and the United States, a knowledge of the methods of control under western conditions and ability to recognize the injury of the insect in its incipient stages will enable the farmers to be forewarned and in a position, therefore, to avoid losses that are liable to occur where the insect is present. The Hessian-fly is believed to have been introduced from Europe, and its habits differ according to latitude and physiographic conditions, etc. It has generally been supposed, heretofore, that the insect produced a single brood only in Manitoba. Mr. Criddle's investigations have shown that a partial second or summer brood also occurs.

The Western Wheat-stem Saw-fly is an example of a native insect, previously living in wild native grasses, that has turned its attention to cultivated grasses when these are introduced with the opening up of new country, and thus becoming a pest by reason of the large amount of one species of a suitable food plant being present. In certain regions of the prairie provinces the attacks of this insect have been severe during recent years, although the cause of the losses was not usually recognized. The study of the life-history and habits carried out by Mr. Criddle has made it possible to recommend control measures suitable to the western provinces, as these measures must necessarily be based upon such knowledge and upon a thorough acquaintance with the agricultural methods of the region.

It is hoped that, by means of the information and illustrations contained in this publication, farmers will make themselves familiar with these two pests and thus be in a position to prevent or control outbreaks that would otherwise diminish their crop production.

I have the honour to be, Sir,

Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

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The Hessian-fly and The Western Wheat-stem Saw-fly

In MANITOBA, SASKATCHEWAN and ALBERTA.

By NORMAN CRIDDLE, *Field Officer.*

PART I.

THE HESSIAN-FLY (*Mayetiola destructor* Say).

SUMMARY.

The Hessian-fly is an insect that has taken enormous toll from the farmers of North America, the aggregate amounting to many millions of dollars. It is supposed to have been introduced into Long Island, New York, about the year 1776, and has since been found over most of the wheat-growing area of North America. It probably reached Manitoba during the middle eighties, though no definite records of its appearance in that province are available before the year 1899. Its first authentic appearance in the West, however, was the occasion of a severe outbreak in midsummer, when damage was done in Manitoba estimated at from 10 to 30 per cent of the wheat crop, while the depredations extended westward as far as Moosejaw, Sask. A less extensive outbreak took place in 1902, again chiefly noticeable in the summer brood. Since then several minor attacks have occurred, which on some occasions considerably thinned out the young wheat plants in spring time. The infestations at this time, however, are often overlooked, or put down to other causes, such as failure of the seed to germinate, wireworms, or drought.

The adult Hessian-fly is a dusky, two-winged, gnat-like insect superficially not unlike a very minute mosquito. The adults appear from overwintering puparia, commonly called "flax seeds", during the latter half of May. Eggs are deposited immediately after the flies emerge. They are very minute, narrow, reddish objects, and may be usually located along the creases on the upper surface of the leaves. From these eggs hatch small maggots which at once work their way down to the bases of the young plants, where they become stationary. Fully developed larvæ are somewhat slug-like in shape and white, or greenish-white, in colour. These turn to puparia ("flax seeds") during the latter half of June, a majority of them remaining in this condition until the following spring. The puparia are not unlike true flax seeds in colour, and resemble them in shape, hence the name; they are smaller, narrower, and less flat.

About 20 per cent of the spring "flax seeds" produce flies towards the end of June and first part of July, a few continuing to appear throughout the latter month and even rarely into August. This generation attacks the plants, as a rule, just above the second joint, the injury being recognized by the well-known bending of the stems after winds or rain. Puparia from this brood do not produce flies until the following spring, when they appear with the remaining portion of the spring brood. Under favourable weather conditions there is probably a variation in the number of flies emerging from the spring brood in June, the percentage being presumably much larger.

Injury in spring is confined to young plants often containing but a few leaves. It may be recognized at first by an unusual blueness of the leaves and by the absence of vigorous, terminal shoots. Later the plants become yellow and die, though occasionally they will survive by sending out fresh sprouts to one side. Puparia of this brood are located near the roots below the ground. In the summer brood they may be found just below the break near the second joint of the stem of the plant.

Plants attacked are wheat, rye, barley, and occasionally a few grasses.

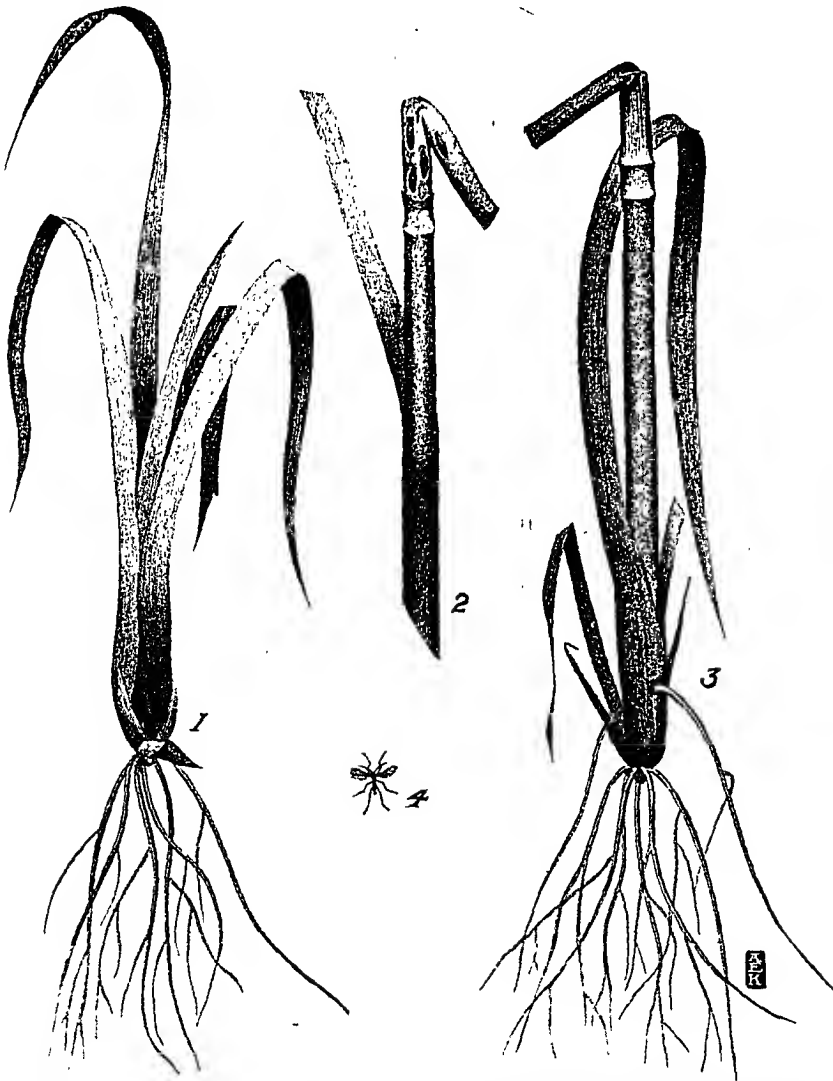


FIG. 1.—Showing typical injury by the Hessian-fly, *Mayetiola destructor*: 1, spring wheat plant destroyed in early June, with puparia, or "flax seeds," near the roots; 2, part of a wheat plant in late July with sheath removed showing puparia above second joint; 3, characteristic bending of the stem caused by the summer brood; 4, adult fly. All figures natural size. (Original).

Control measures consist of: (1) Ploughing all infested stubble land between August 15 and the middle of May of the following season, ploughing to be not less than 5 inches deep; "spring ploughing should be packed. (2) Burn all stubble and straw piles between the dates mentioned above. (3) Carefully gather up all screenings and use the same as feed, or destroy before May 15.

(4) Infested land unable to be treated by ploughing or burning at the proper time should be disked or cultivated as soon as possible and ploughed down before June 20. (5) Sowing strips of grain about 20 feet wide between infested stubble and newly planted grain to attract flies may be resorted to on occasions of severe outbreak. The strips should be planted early and ploughed down about the middle of June. (6) Prepare a good seed-bed and use the best of seed. Vigorous plants will be more able to resist attack; weak ones are easily killed out.

Climatic conditions are of considerable importance as factors in determining the numbers of flies that will appear in any given season. Years in which there is an excess of rainfall combined with warmth, particularly in early summer, will favour the insect's development, while excessive dryness will have an exactly opposite effect.

Parasites are also of great importance, and usually may be sufficient to control the pest in time. All such natural aids, however, must be considered as of minor importance and should not in any way be relied upon by farmers at periods of severe outbreaks.

Early maturing wheat would probably be less likely to suffer than late-ripening kinds, and in this respect the variety *Prelude* might escape most of the summer brood, while barley by being sown after June 1 will escape nearly all the spring attack and yet have time to ripen; the same can be said of rye as a general rule, though an occasional season may prove unsuitable.

Co-operation is essential in the suppression of all severe insect outbreaks. Flies may easily fly from one field to infest another in the vicinity. Good cultivation is also of much value in enabling plants to resist attack.

INTRODUCTION.

The Hessian-fly has long been recognized as one of the worst pests to cereal crops that farmers of North America have had to contend against. Discovered more than a hundred years ago on Long Island, New York, it has since gradually made its way over the wheat-growing area of the continent, causing enormous losses in nearly every place it has visited. While, however, it has taken heavy toll from the farmers of the United States, and caused much loss at times in Eastern Canada, its depredations have been, on the whole, less in the western provinces, and we have but two records of severe infestation since the insect was first observed there in 1899. Its presence, however, has been continuous since the time of its first introduction, and on several occasions since then far greater toll has been exacted from the farmers than is generally supposed. Small losses take place nearly every year, which with favourable weather conditions and the absence of parasites, would probably soon be multiplied to serious proportions. Much of these losses, however, might be avoided were farmers acquainted with the insect causing them.

Until quite recently it was supposed that the Hessian-fly produced but a single brood in Manitoba, the supposition being that the season, combined with the small amount of fall wheat grown, precluded the possibility of two broods developing. The only attack recognized, therefore, was that which appeared in summer and caused the broken stems in July. It gradually began to be suspected, however, that there was an error in this diagnosis and, in 1903, the writer commenced to make some studies of the insect's life-history with a view to settling once for all the facts of the case, and also devising, if possible, practical remedies. While these investigations were partly successful it was not, however, until joining the staff of the Entomological Branch, in 1913, that sufficient time and opportunity occurred to permit the final completion of this undertaking.

The life-cycle as here described is that under which the insect passes during normal climatic conditions as they have been in Manitoba, Saskatchewan, and

Alberta during the last five years. These seasons, however, were in many parts unusually dry and therefore unfavourable to the development of the flies.

HISTORY OF INTRODUCTION INTO WESTERN CANADA

The Hessian-fly was first definitely recorded from Manitoba by Dr. James Fletcher during the year 1899¹. It had, however, been reported by correspondents the previous season and, in all probability, invaded the province with the rush of settlers some years earlier. From whence it came, or how it was introduced will remain a mystery. It could, of course, have easily been introduced from the east in straw, but as it was recorded in numbers from Iowa, Minnesota, and the borders of South Dakota, in 1896, there is every reason to suspect that it crossed the boundary from the south, having gradually worked its way west and north from the original place of introduction in New York state.

Curiously enough, the most severe outbreak ever experienced in Western Canada was in 1899, the year of the insect's first authentic appearance, and on that occasion the attack practically covered the whole area under wheat crop, being worst in the older settlements along the Red River valley and extending west as far as Moose Jaw, Sask. The loss on that occasion is said to have varied from 10 to 30 per cent; but unfortunately no trained observer was on the spot; consequently exact data are lacking. For instance, no mention is made of spring injury, though we now know that the fly must have been present at that time. We are also in the dark as to its prevalence the previous season, though, as mentioned by Fletcher, it had been reported from Manitoba, these reports, however, being without verification.

The following year, as is so often the case with Hessian-fly outbreaks, was practically free from infestation; in fact, no records were made of its presence, though a severe outbreak took place in Ontario. We have no further information of injury in Manitoba or westward until 1902, a period of three years. At this date, however, another rather extensive outbreak took place, being again particularly noticeable in August, though a few observers on this occasion also reported spring injury.² Since 1902, several minor infestations have occurred, the attack being confined largely to young plants in early June. The presence of the insects, however, has been quite widespread in Manitoba for several years past and, in 1913, I found it even more numerous near the borders of Saskatchewan than farther east. No thorough survey has been made of the insect's distribution west of Manitoba, though reports to the Entomological Branch from correspondents in various parts of Saskatchewan would indicate that it is quite widely spread over that province.³

Our information regarding the insect's presence in Alberta is still more meagre; and we have no reliable data of its establishment there until the year 1911. In this year several farmers complained of injury to spring wheat in the southern portion of the province, the attack being noticed in August due to the bending of the stems. Specimens of infested straw sent in for determination left no doubt as to the identity of the insect, consequently its distribution over at least a portion of all the above-mentioned three provinces is no longer in question, while its spread over the whole wheat-producing area is presumably only a matter of time.

DESCRIPTION

Egg.—The egg is clear, light-reddish, linear-cylindrical in outline, and very small, approximating one-fortieth of an inch in length.

¹ Ann. Rept. Ent. and Bot., Dom. Exp. Farms, Ottawa, 1899.

² Same Report as above for 1902.

³ We are indebted to Prof. T. N. Willing, of the University of Saskatchewan, Saskatoon, Sask., for data on distribution in that province.

Larva.—The larva when first hatched from the egg, is seldom met with in the first stage owing to its small size. At this time it is quite active, and can readily make its way down to the position in which it is usually found later. In the second stage the larvæ become stationary and are flattened, almost slug-like objects, white or greenish—white in colour and more or less transparent. From this condition they change in due course to puparia (commonly called “flax seeds”) by a hardening of the outer skin, in which the larvæ may remain for several months without feeding.

Puparium, or “Flax seed”.—The puparium is about three-tenths of an inch long, semi-oval in outline and usually tapering to a point at one end; the colour is dark chestnut-brown. The resemblance to a flax-seed is only superficial; as a matter of fact, this term might be misleading to those well acquainted with the seed of flax, the puparium generally differing in being smaller, narrower, less flat, and darker.

The true pupæ are found within the puparia, and apparently change to that stage only a short time before the flies emerge.

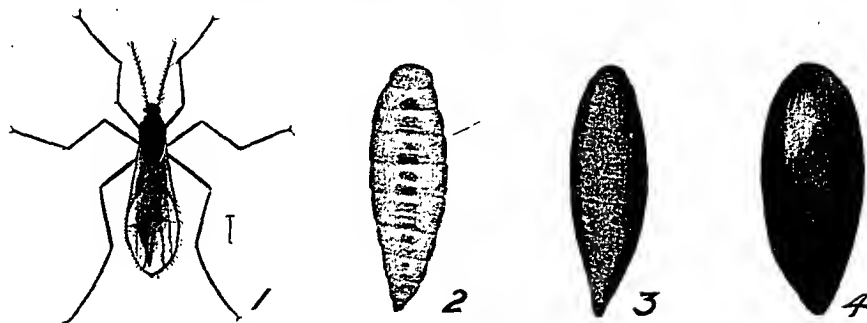


FIG. 2.—The Hessian-fly, *Mayetiola destructor*. 1, adult female fly; 2, mature larva; 3, puparium, or “flax seed”; 4, seed of cultivated flax.—Enlarged about 8 times. (Original).

Adult.—The adult Hessian-fly is a slender, two-winged, gnat-like insect which for comparison might be likened to a very small mosquito without, of course, the piercing mouth parts. It is dusky in colour, but in the female the abdomen has a dull reddish tinge particularly between the segments, while the male, which is less stout, is almost uniformly greyish-black. In both sexes the wings are seen to be covered with fine black hairs; when viewed through a lens, they are also distinctly fringed, though these features are hardly discernible with the naked eye. The average length of female flies is one-tenth of an inch and their total width across the wings a quarter of an inch. Males are rather smaller.

LIFE-HISTORY

As was suspected years ago by Webster, and as it has been since abundantly demonstrated, the life-history of the Hessian-fly differs considerably according to the latitude and geographical conditions under which it occurs. Moisture and temperature also play a very important part in the development of the insect, and extremes in any of these would almost certainly alter the normal life-history.

In Manitoba, at 49.5 degrees of latitude, which is farther north than the insect has hitherto been studied on this continent, there is only one full brood, with a supplementary summer brood usually averaging about 20 per cent of the spring brood, but probably reaching far larger proportions under favourable weather conditions.

It is interesting to note that Webster¹, discussing the habits of the fly in North Dakota, remarks that “the breeding season extends from about May 20

¹ Circular No. 70, Bureau of Entomology U. S. Dept. of Agriculture.

to October 1, or throughout the entire summer." The season, however, when the observations were made was a favourable one for the insect's development. At Treesbank, Man., I have been unable to breed or discover flies later than August 18; in fact the number reared after the end of July is very small. Thus, I can find no evidence of a fall brood, though under very favourable conditions it is conceivable that a few flies might appear. The complete life-history in Manitoba, as worked out two years in succession, is as follows:—

Spring Brood.—Flies emerge from over-wintering puparia about May 15, and continue to appear in numbers to the end of that month, while odd individuals may be found up to June 15, their appearance depending somewhat upon seasonal conditions. Eggs are deposited almost immediately after the flies appear. They may be found upon the upper surfaces of leaves, and along their crevices, in numbers varying from one to ten or more. Rarely, the eggs may be located on the under side or even on the stems, but it seems doubtful whether the larvæ from these, unless they could make their way to the upper surface, would be able to reach the necessary location between the leaves, and this is probably why eggs are generally placed upon the upper surface. From these eggs the larvæ hatch in from ten to twelve days, depending upon the weather, and the young maggots immediately work their way down between the sheaths towards the roots, stationing themselves at the base of the plant and eventually killing the shoot, but not necessarily the plant itself which may send out other sprouts. To quote from Webster: "The young make their way down the plant head foremost and so remain until before pupating, when they reverse their position in the 'flax seed' and are then situated head upmost." Puparia develop the second half of June, and may be found clustered among the dead leaves about an inch below the ground in numbers varying from one to ten or more.

Summer Brood.—From about 20 per cent of the spring brood, flies commence to appear the latter part of June, increasing in numbers until about the 10th of July, when they gradually diminish, a few, however, appearing at odd intervals up to the end of the first week of August or even as late as the 18th. Eggs from the June and most of the July flies are, as a rule, deposited on leaves above the second joint, and larvæ are to be found clustered irregularly, often partly buried in the straw, just above that joint. Puparia develop late in July, and the winter is passed in that state. Flies emerging late in July or early August would generally find wheat plants too far advanced for the development of larvæ. Under these circumstances they have been found to attack late barley and volunteer wheat. All puparia of the summer brood remain dormant until the following May, when they produce flies with the remaining portion of the spring generation.

It will be seen from the above that about 20 per cent. of the flies from the spring brood constitute a second brood under average normal conditions, but there is every reason for expecting a far larger summer emergence when the weather is usually favourable. Unless this were so in 1899 the spring generation must have caused very great injury, of which there is no record.

There does not seem to be any evidence in favour of a true autumn brood, but in any case the proportion of winter wheat grown in the Middle West is small and the area is not sufficiently concentrated to enable the flies to multiply unless aided by volunteer growth.

INJURY AND HOW RECOGNIZED

In spring time it is almost impossible to distinguish Hessian-fly injury from that of the various wheat-stem maggots with which it is generally associated. The young plants, often containing but three or four leaves, at first show an unusual bluish tint, while the central shoot is stunted; later they become yellow

at the tips and eventually either die outright or survive by throwing out new shoots to take the place of those killed. In years of severe infestation, large patches of grain, more often in the lower spots, will be practically destroyed and the whole field will have an uneven look as if the grain had failed to germinate. A closer inspection, however, reveals the dead plants with the puparia in position among the leaves below the ground.

The injury from wheat stem-maggots (both *Meromyza* and *Oscinis* spp.), though very similar to Hessian-fly attack, is usually distinguished by the central shoot being killed and a single outer leaf remaining green. The puparia, too, are quite different. In the summer brood of the Hessian-fly, injury is nearly always just above the second joint, though it may occur at the first or third joint. Usually the stem, by the characteristic bending over, at once reveals the nature of the injury. This is a very constant character during late July and early August. Other insects may weaken the straw sufficiently to cause it to blow over, but the breakage is seldom just above the joints. Examination of the straw at this spot will always reveal fully developed larvæ or "flax seeds" if the work is that of the Hessian-fly.

The injury caused by the few Hessian-flies that deposit eggs upon volunteer cereals will be similar to that described in the spring brood, puparia being below the ground among the leaves near the roots.

FOOD PLANTS

The attack of the Hessian-fly is usually confined to wheat, rye, and barley, though it probably also infests speltz, and has been found in grasses such as the Western Rye grass, *Agropyron tenerum*, and also a few other species belonging to that genus. We might also expect it to infest Barley Grass, *Hordium jubatum*. The attack upon grasses, however, seems to be very light and hardly worthy of serious attention.

MEANS OF DISTRIBUTION

There seems to be but two channels of distribution, namely, by the flight of flies and by artificial spread through the carriage of puparia in straw, etc. From careful computation of several authorities, flies probably spread at the rate of about 20 miles yearly; this, of course, depends upon weather conditions, especially the prevailing winds. Unless there were several favourable seasons in succession, distribution by flight would not, therefore, be rapid; but as the puparia occur in abundance in straw they might easily be carried across the continent in packing cases and other containers in which straw is used. They could also be distributed in screenings where they often occur in large numbers, and occasionally even in shipments of grain.

NATURAL ENEMIES.

Little work as yet, has been conducted to ascertain what natural enemies of the Hessian-fly are present in Western Canada, chiefly owing to the comparative scarcity of the insect in recent years. There is no doubt, however, that large numbers of hymenopterous parasites are sometimes present which are factors of much importance in checking the pest; indeed, there is every reason for believing that these parasites would alone be sufficient to suppress infestations in time, but it is unwise, as a general principle, to rely entirely upon natural means of control, as severe losses are apt to occur before that is accomplished.

Headlee and Parker¹ report the presence of a wireworm larva in Kansas which had eaten into the centre of wheat plants and, in doing so, destroyed Hessian-fly puparia. I have also noted the same kind of attack in Manitoba on several occasions, but while there is no doubt that "flax seeds" were destroyed, other plants were found attacked which contained no sign of fly infestation, consequently it seems probable that the destruction of puparia was accidental.

RELATION TO CLIMATIC CONDITIONS

It is a noteworthy fact that outbreaks of Hessian-fly are always very spasmodic. The insect may increase at an enormous rate and in sufficient numbers to endanger the total product, and then, when it appears to threaten the entire crop, it suddenly decreases to comparatively insignificant proportions. There is no doubt that parasites play an important part in these reductions, but a factor of probably still greater importance in the Prairie Provinces appears to be that of humidity, combined to some extent with temperature.

An examination of the meteorological records from Manitoba, covering the period of our worst infestation, reveals the fact that there was an unusually heavy snowfall during the winter of 1898-9. The spring was late, following heavy snow. The month of May produced a moderate rainfall, June an excessive one, while the spring, though late, was afterwards unusually warm, providing conditions that are recognized as favourable for the development of the insect. From August to winter the rainfall was very light, and this was followed by a very dry spring in 1900, continuing until June 27, thus producing conditions most unfavourable to the fly and which were doubtless instrumental in reducing the insect to insignificant numbers during 1900. Somewhat similar conditions prevailed during and after the outbreak of 1902. Another interesting example of the effects of drought was noted during 1914 when lack of rain caused a premature ripening of crops, thus drying up the stems before the larvæ were fully developed and, therefore, while most of them were able to enter the flax-seed stage, few survived to produce flies.

These facts, combined with the observations of others, would lead us to suspect that the somewhat dry climate prevailing in most parts of the Prairie Provinces will always prove a check to the continuous prevalence of Hessian-fly in large numbers. Good crop years, however, may well prove good fly years, and so it behooves farmers to be on their guard at all times.

METHODS OF CONTROL

As there is no evidence of a fall brood of Hessian-fly in the Middle West, control measures are comparatively simple and may be accomplished, as a rule, with little loss of time and small inconvenience of farmers. In the recommendations presented below, only those measures of known value are given, while others, not considered practical, have been purposely omitted.

Ploughing.—Investigations have shown that very few flies are able to make their way through 3 inches of soil though they have no difficulty in forcing their way through 1 inch when the old plants they infested are still present to aid as a guide. As it is impossible, however, to plough soil so that all portions of the furrow are equally deep, it is found advisable to recommend a depth slightly in excess of what would be necessary could the soil be turned to cover all parts of the upper surface evenly. *Ploughing under all infested stubble land, not less than 5 inches deep, between August 15 and middle of May of the following year, is the best of all remedies and will, if carefully done, practically check every attack.* Fall ploughing will, of course, pack sufficiently with the winter snows and early rains to fill in any cracks or crannies, but in spring time it is advisable to follow

¹ Bulletin No. 188, Kansas State Agricultural College, 1913.

ploughing with the harrow, or better still with a packer, thus providing a firm seed-bed through which the flies are unable to make their way to the surface.

Burning.—When practicable, all stubble suspected of harbouring “flax seeds,” or where the fly is known to have occurred, should be burnt over as soon as possible after harvest or not later than May 15 of the following spring. This will destroy all the summer brood not collected by the binder, but will not injure the spring brood, which it must be remembered is below the ground. It is also important to destroy all screenings from the threshing machine, either by feeding to stock or by burning, as these often contain large numbers of puparia. The straw of wheat, rye, and barley should also be got rid of before the middle of May, otherwise many of the “flax seeds” located in it will produce flies.

A combination of the above remedial measures, if carefully followed should be sufficient to control any outbreak. It must be remembered, however, that some sort of co-operation is necessary in carrying out these recommendations, for while one farmer may follow them to the letter, the neglect of his neighbours might still be responsible for the entire loss of his crop.

Trap Crops.—In the past, sowing a narrow strip of either wheat, rye, or barley between the growing grain and an infested stubble field has often been suggested and recommended as useful, though in late years it has fallen into disrepute, and, in any case, is not to be compared with measures described above. There are, however, occasions when it might be practised to advantage. The strip of land need not necessarily be ploughed, either disking or sowing with a disk drill is sufficient. The idea is to provide an early stand which is sufficiently advanced to attract and retain the flies as they hatch out; in other words, to cause them to deposit their eggs upon these plants instead of flying to the grain fields in the vicinity. The strip should be about 20 feet wide, and must be ploughed down before June 15.

Disking or Harrowing.—In cases where ploughing the land is impossible, disking or cultivating the infested stubble fields will kill many of the insects, besides starting various weed seeds. It also favours volunteer wheat upon which the flies lay their eggs instead of flying to the crop to do so. If possible, this should be ploughed down in June, but numerous flies will be destroyed even if it is not turned down until July.

Cultural Methods.—Any method whereby the plants are strengthened will be useful in enabling them to withstand attack. We are taking it for granted, to begin with, that the best available seed is used for sowing. As to cultivation, a farmer should know from experience what suits his land best. We might suggest, however, deep ploughing, the land to be later formed into a good seed-bed by means of a harrow, cultivator, or packer, as may be necessary or convenient; generally speaking, a firm seed-bed with a loose surface is considered to be ideal. Hessian-fly attacks are generally less injurious under such conditions, and more severe when the land is loose and rough.

Destruction of Volunteer Wheat.—While the Hessian fly does not actually attack volunteer wheat to any great extent in Western Canada, it is nevertheless sometimes present in it, as are also various wheat-stem maggots. It is therefore advisable to check such growth by cultivation or feeding.

Resistant Types of Grain.—So far as is known, no types of wheat, rye, or barley are immune from the attack of the Hessian-fly, though some may be more favourable to the development of the insect than others. Early-maturing wheat would doubtless be less liable to suffer from the summer brood than late-ripening kinds; it is very doubtful whether that generation would have time to mature on such varieties as Prelude, and in this respect even Marquis would have an advantage over Red Fife.

Barley, by being sown after June 1, would escape nearly all the spring attack and yet have plenty of time to mature. This would also apply to rye under ordinary seasonal conditions.

PART II.

THE WESTERN WHEAT-STEM SAW-FLY (*Cephus occidentalis* R. and M.).

SUMMARY

The Western Wheat-stem Saw-fly is a native of North America, and originally lived in various wild grasses, but chiefly in those belonging to the genus *Agropyron*, commonly known as wheat grass, rye grass, or bunch grass. Briefly described, the adult insect is a blackish, four-winged fly about one-third of an inch long, with three prominent yellow rings upon the abdomen, and with yellow legs. It can usually be recognized by its habit of resting head downwards upon stems of grasses or grain, as the case may be, with its wings held very close together over the back.

The larva, or grub, is slightly less than half an inch long when mature. It is yellowish-white in colour, and has a thick, short, tail-like process protruding behind. The larva always occurs within the stem.

In the past the prevalence of the Western Wheat-stem Saw-fly was largely influenced by the growth of its food plants. When these bore flowering heads in plenty, the fly increased. When, from any cause, they failed to do so, the insect, having less to feed upon, was reduced correspondingly.

With the arrival of settlers and the planting of grain, conditions changed. Wheat and rye were found equally suitable to the Saw-fly for breeding purposes; consequently, when its natural food plants failed it had only to fly to the growing grain, where it found everything favourable for its development and increase.

Of recent years the loss by this pest has been quite severe in portions of the Prairie Provinces, though the insect has not always been recognized. It has maintained itself in the grain fields with little reduction since 1907, and in 1914 infested 75 per cent of the straws on the edges of certain fields.

Flies, appear, as a rule, during the second week in June, and may be met with until about July 10, though most of the eggs have been deposited before the end of the former month. Larvæ are present in the straws in early July, at first above the upper joint. Later, they work their way downwards, eating out the inner tissues of the stems as they go. They reach the roots by the first of August, cut the stems through level with the ground and then, after lining and plugging the stub, remain in it until the following June, when they emerge as flies. Injury is generally recognized by the breaking of straws after wind or rain in late July, the breaking down looking not unlike the work of hail. Just before harvest, stems will be seen to have been cut off close to the ground and to have fallen in all directions. Earlier a blackening of the stems near the joints is also an indication of sawfly injury, but in all cases an examination of the inside of the stems will reveal the customary tunnelling through the joints, and the dust left by the grub at various points.

Remedies.—(1) Plough all infested stubble down not less than 5 inches deep between the first of August and last of May of the following year, to be followed by some method of packing when the ploughing is done in spring. (2) When ploughing cannot be accomplished over the whole area, an attempt should be made to turn down those portions of the field where the sawflies were most numerous, this being in the first hundred feet or two next to last season's grain fields, and after July on the edges of recently harvested crops. (3) All infested grasses, such as Western Rye grass, timothy, and the prairie grasses, next to growing crops, should be cut between July 10 and August 1. By this means the larvæ will be caught in the straws before they can reach the ground, and will thus perish from lack of proper nourishment.

When only a small area is under cultivation, the sowing of oats or root crops instead of wheat, rye, or barley, would free the land and either kill or cause the fly to return to wild grasses.

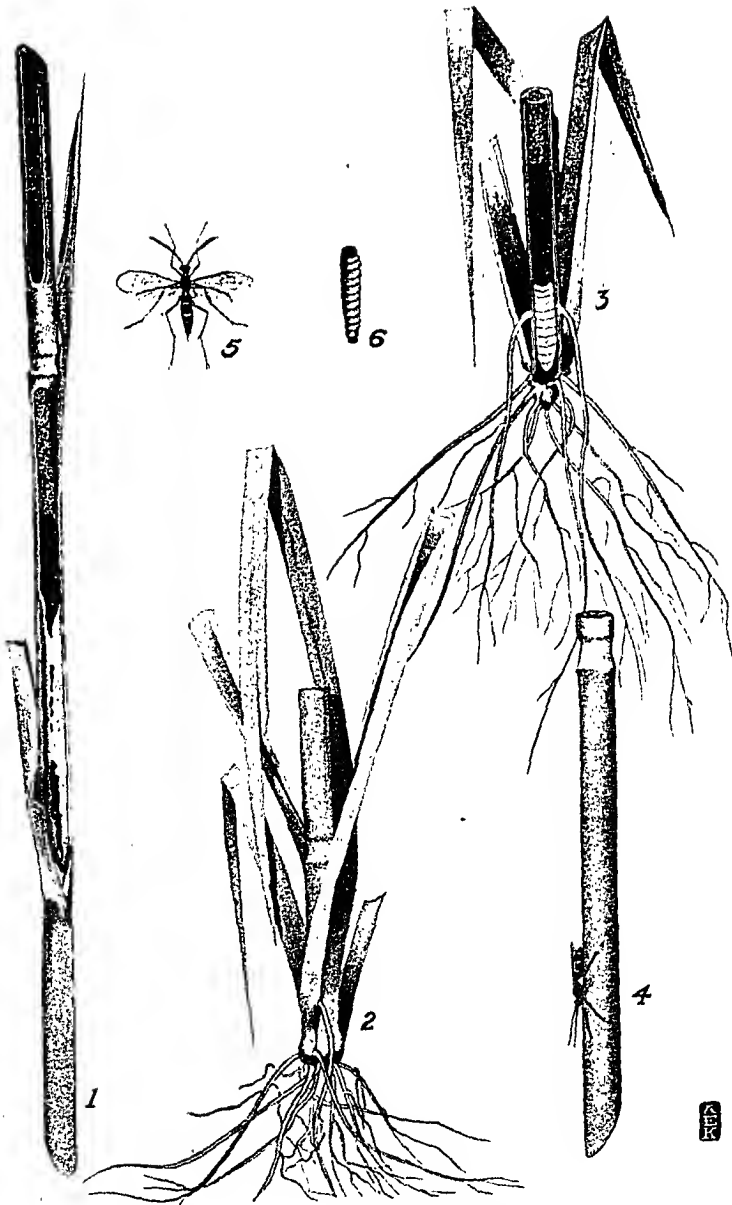


FIG. 3.—The Wheat-stem Saw-fly, *Cephus occidentalis* R. & M.: 1, straw cut open to show tunnelling of larva; 2, base of plant showing how stem is severed near the ground; 3, stub, or base, with larva in winter position; 4, portion of stem showing characteristic resting attitude of saw-fly; 5, female saw-fly; 6, mature larva. The powdery deposits shown in the stem (Figs. 1 and 3) are the grass and borings left by the larvæ. All figures natural size. (Original).

INTRODUCTION.

In its original condition, before the advent of the farmer settler, the Western Wheat-stem Saw-fly bred in a few native grasses, chiefly belonging to the genus *Agropyron*, of which our common rye or wheat grass is an example. It was then of small economic importance, and depended for its existence, apart from control by parasites, upon the number of flowering stems produced by the plants upon

which it fed. Two or three years of plenty upon the prairies would enable the insect to multiply extensively, while a sudden decrease in the flowering stems through climatic causes, would reduce the Saw-fly in proportion to the heads produced. Thus, it fluctuated from year to year until mankind, in the form of settlers, upset the balance of nature by sowing cereals, so that henceforth the Saw-fly was no longer dependent upon the native grasses for subsistence. Instead, all that was necessary was for the insect to fly to the grain fields where a far greater abundance of food awaited it than had ever before been available.

It is interesting to know that even in the days of the early settlers, the Sawfly still preferred its native food plants, and so long as they were plentiful enough it seldom attacked the crops. Indeed, I have known it to fly some distance into the grain and select the stems of Bearded Wheat-grass, *Agropyron richardsoni*, in preference to the wheat growing round about.

In 1906, there was an enormous outbreak of the Sawfly in Manitoba, practically every grass stem of *Agropyron* and *Elymus* being infested, while here and there a few wheat stems were also attacked. In 1907, there was another severe outbreak, more than the native grasses were able to accommodate, and, consequently, the Saw-flies flew in large numbers to the growing grain, depositing their eggs upon wheat and rye, which suffered severely in some places. Indeed, odd fields were almost entirely cut down along their edges, while the injury extended several hundred feet into the crop, becoming, as is customary, gradually less severe towards the centre. Since this original infestation, the insect seems to have changed its habits and, instead of preferring wild grasses, it selects with equal readiness the stems of wheat and rye, flying each year from the old stubble to the new crop.

While this pest has never been as prevalent as the Hessian-fly was in 1899, it has, nevertheless, proved far more persistent in its depredations, doubtless due to its being a native and consequently not suffering so severely from the vicissitudes of climate. That it may, like the Hessian-fly, be kept under control by proper cultural methods there is no doubt, but unless those methods are adopted the insect may at any time become a very serious pest.

ORIGIN AND DISTRIBUTION.

The Western Wheat-stem Saw-fly, or, as it is sometimes called, the Grass-stem Saw-fly, is indigenous to North America, and was described by Riley and Marlatt from specimens, collected in 1890, from California, Nevada, and Montana.

The first record of its occurrence in Canada dates from 1895, when Dr. James Fletcher collected adults by sweeping at Indian Head on July 5. It was also reported as causing injury at Indian Head, Sask., and Souris, Man., in 1896, and fully treated of under the name of *Cephus pygmaeus*, in the report of the Entomologist and Botanist of the Dominion Experimental Farms for that year.

There is little doubt that this insect occurs over a large portion of North America, having apparently a preference for the spring-wheat growing regions where native bunch grasses (*Agropyron* and *Elymus* spp.) are abundant. Prof. F. M. Webster¹ describes it as occurring in the "Dakotas, Nebraska, Kansas (?), Montana, Wyoming, Colorado, Oregon, Nevada, and California," while in Canada it has been taken from almost the eastern border of Manitoba westward to the Rockies, and there is little doubt that it also occurs in the drier parts of British Columbia. We have no records of the insect east of Manitoba, nor is it probably that it will ever become a serious pest in those regions where winter wheat largely takes the place of spring wheat.

¹ Circular No. 117, Bureau of Ent., U. S. Dept. of Agric., 1910.

DESCRIPTION

Egg.—The egg is a minute, white, cylindrical object, too small to be readily observed unless the fly is seen depositing it.

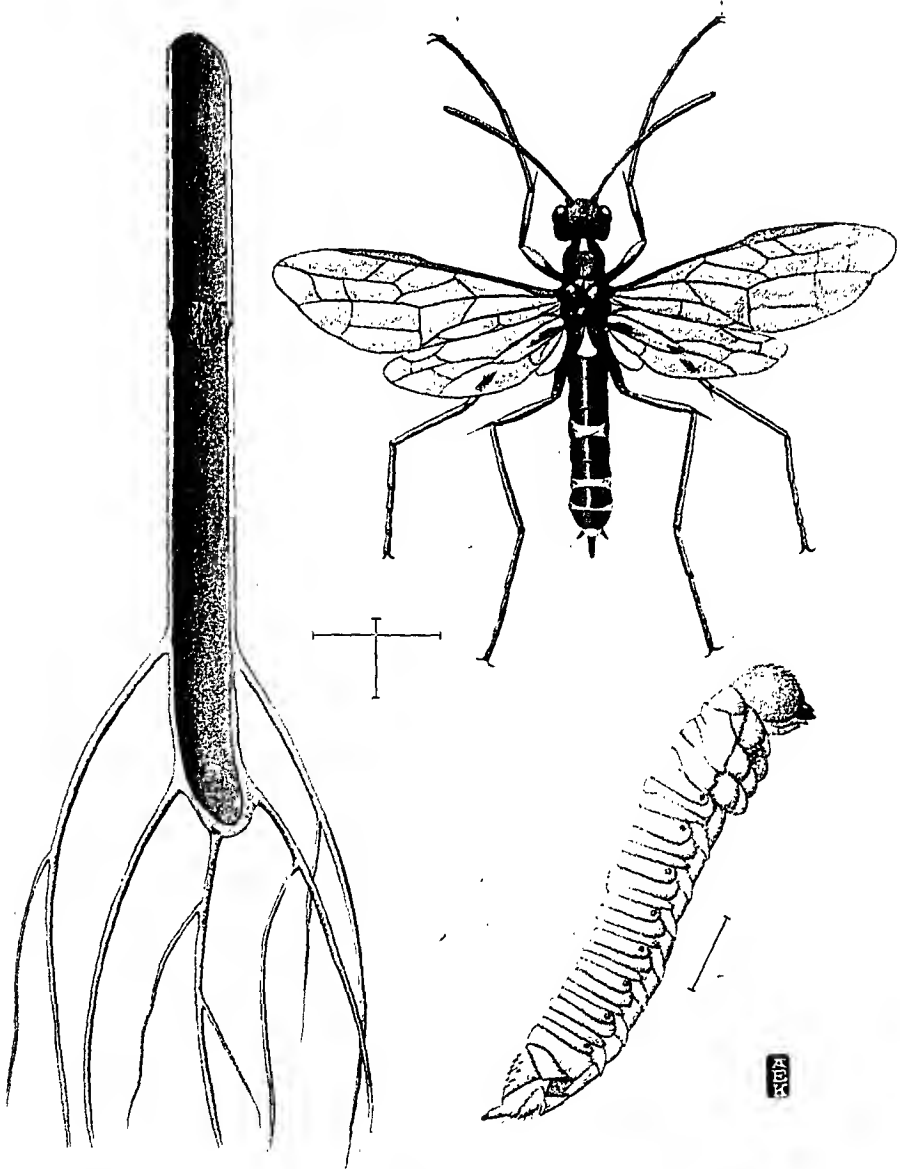


FIG. 4.—Showing adult saw-fly, adult larva, and portion of injured plants, cut open to indicate gnawing of stem by the larva, which causes stem to break off at that point—much enlarged. Hair lines indicate natural size of saw-fly and maggot. (Original).

Larva.—This is a dull, yellowish-white grub, slightly less than half an inch in length when fully developed. The first two segments are somewhat swollen, and there is a short, blunt point protuding from the hind end of the body, which readily separates this larva from others found infesting growing grain in Western Canada.

Pupa.—The pupa is developed in May within the stub inhabited by the larva.

Adult.—The adult Saw-fly is a shiny-black, four-winged insect, with three prominent yellow, wasp-like rings on the abdomen, and with legs in which all but the basal portion are bright yellow in the female, and in the male entirely so. In addition, the female has a short, stout, horn-like appendage at the end of the body, used for depositing eggs. The length of the female is approximately one-third of an inch; that of the male somewhat shorter. To a farmer the adult Saw-fly might well be mistaken for a narrow-bodied wasp, though in reality it has no sting. In nature it may generally be recognized by its characteristic habit of resting head downwards upon the stems of various grasses and grains, with its wings held very close together over the body.

LIFE-HISTORY.

Like most insect pests, the emergence of adults and general life-history of the Western Wheat-stem Saw-fly are governed to some extent by climatic conditions. In an ordinary season, however, the flies commence to appear about the second week in June, when they may be found at all times of the day resting head downwards upon the stems of various grasses, as well as upon those of cereals, particularly wheat and rye. During cold weather the flies are practically inactive, remaining stationary in their characteristic head-downwards position, but with the return of warmth and sunshine they become active, and towards the end of the month are busily engaged laying eggs.

The eggs are deposited by the females, while still resting head downwards; while thus occupied she draws the abdomen well under her body and then thrusts the ovipositor into the leaf sheath so that she can place her egg above the topmost joint. In the only cases observed, the eggs were deposited on the outside of the stem, that is between it and the innermost sheath, but fastened to the former, the grass head not being visible. Whether this is the general custom or not, I am unable to say. I have, however, observed a female try a stem, and apparently finding that she could not reach the spot desired, withdraw her ovipositor and fly to another plant to repeat the performance until she eventually became satisfied.

Whether the egg is deposited in the stem or not, or whether, as it has been observed, it is deposited on the outside of the stem, the young larva is, at all events, located inside the stem, generally above the topmost joint, but occasionally below it. The egg evidently takes but a short time to hatch, probably not more than three or four days, as the larvæ can generally be found in numbers by July 1. From the point where it hatches the larva works its way to within a short distance of the lowest joint and, by about August 1, has reached the ground. At the former date, the grasses all show the effect of being attacked, owing to the heads turning white. Wheat seems to suffer much less, probably on account of the size of the straw. The heads of late-sown wheat or rye, however, nearly always turn white, and the work of the Sawfly is then difficult to tell at a glance from that of the Greater Wheat-stem Maggot (*Meromyza americana* Fitch). Having arrived at the basal portion of the stem, the larva gnaws a ring around it on the inside, and in so doing almost cuts the stem through so that it readily falls away from the lower portion with the first puff of wind. In this basal portion, from which the straw has been severed level with the ground, the larva constructs a loose cocoon, first stopping up the upper end with matter gnawed from the inside. In this cocoon the larva passes the winter and remains without feeding for approximately nine months, that is to say from the first week in August until the following May. It then changes to a pupa and emerges as a fully developed saw-fly towards the middle of June. The date of emergence, however, depends somewhat upon the season. With a warm early spring, saw-flies have appeared the first week in June. In late seasons they may not emerge until almost the end of that month. The life of the

adult is approximately twenty days, but owing to fluctuations in the time of its appearance, as mentioned above, it might be present at any time during a period of say forty days, or in other words, from about the first week in June until the middle of July, during any portion of which period the females might be ovipositing.

On emerging, the adult saw-flies immediately make their way to the nearest larval food plants, where they remain inactive until such time as they are prepared for breeding purposes. They then become active, and the females fly from plant to plant seeking suitable places to deposit eggs. As a rule, however, they are easily satisfied and do not fly long distances when suitable plants are available close at hand. This is the reason why fields of wheat or rye may be almost totally cut down at the edges and yet escape practically untouched towards their centres.

MEANS OF DISTRIBUTION.

Being a native insect, it is doubtful whether this Saw-fly will ever greatly extend its present range by natural spread. As it passes the winter as a larva beneath the ground, and does not seem able to survive in dead straw, the only method whereby it could be distributed is by flight, or by artificial carriage while in the adult stage. As the insect is not a strong flier, it would not fly more than a few miles yearly, while the chances of its flying on to or into objects and being transported immediately to other parts does not seem very probable.

NATURAL ENEMIES.

Usually these appear to be very few, and the Saw-fly seems to have been controlled more by food supply than by parasites. Prof. F. W. Webster, however, records the rearing by Mr. G. I. Reeves¹, of an undescribed chalcid species from the larvæ. I have also observed parasitic infestation, but was unable to rear the species to maturity.

EFFECTS OF CLIMATE.

Inasmuch as a dry season would retard the development of the flowering stems of the plants upon which the insect feeds, dry weather may be said to be indirectly injurious to the Sawfly's development. At times of severe drought, however, the insect is more directly effected, and may be even killed outright. An instance of this was witnessed in 1914 when the premature ripening of wheat due to drought, killed a number of larvæ, besides stunting many more. It appears to be necessary for the flies to have sunshine while ovipositing. Their activities, on the other hand, are much retarded when the temperature is below 60°F. It seems probable, therefore, that a cold, cloudy season might prove as disastrous to the insects as an unusually dry one. The ideal conditions for development would be a moist spring, a dry sunny June, and sufficient moisture during July, to enable the full development of grasses or grains.

INJURY TO THE SAW-FLY THROUGH CHANGE OF FOOD PLANTS.

In its attack upon cereals the Western Wheat-stem Saw-fly has incurred at least one danger to which it was not subject originally. The native grasses in which it previously fed are all stiff in texture, enabling the larva to tunnel up and down without any ill effects, but with wheat or rye, particularly the former

¹Circular No. 117, Bureau of Ent., U. S. Dept. of Agr., 1910.

this is not the case. Infested stems bend over very readily by means of wind or rain and, as the weakest part is not infrequently where the larva is feeding, it is thus often killed in the breaking, or becoming trapped above the break dies by not being able to reach the base of the plant and there make its winter home. After strong winds, fully 20 per cent are often destroyed in this way.

INJURY AND HOW RECOGNIZED.

Usually the first intimation a farmer has of Saw-fly injury is after a heavy wind or rain storm, when he finds his crops broken and bent in all directions, as if a hail storm had struck them, and indeed there are said to be records when hail insurance has actually been paid for damage that was in reality the work of these saw-flies. By cutting open the straws, however, and splitting them down through one of the joints the real nature of the injury will be revealed. The straw will show an unusual hollowness, having been eaten out, as a matter of fact, by the grub. In certain places there will be large quantities of dust left behind by the larva while tunnelling; still further exploration will discover the larva itself, which may be either above or below the break.

During periods of comparative calm weather the stems remain standing much longer, and the injury may then escape detection until the grain is ready to harvest. Usually, however, it is cut by the larvæ some days in advance of the time considered suitable by farmers, and is, therefore, already lying thickly upon the ground when the harvester arrives.

Apart from these very obvious methods of recognition, determination is by no means easy. Early in the year the only method of detection one can suggest is to split the green straws, when the borings of the insect will be revealed. Towards the end of July, the heads are inclined to turn white, when the attack may be confused with that of the Greater Wheat-stem Maggot. In addition to the characteristic tunnelling, however, the straws generally turn blackish near the joints, thus revealing the identity of the insect within.

FOOD PLANTS.

As previously stated, the Western Wheat-stem Saw-fly originally subsisted upon native grasses, these being chiefly species of the genus *Agropyron*, of which the most important in the West are *A. richardsoni* and *A. smithii*, more generally known as Awned Rye grass and Western Couch grass, respectively. The first of these is a true bunch grass, the latter spreads, like the common couch grass, by underground root-stocks. Lyme grass (*Elymus*) is another host plant of some importance, while at least two species of *Calamagrostis*, one of *Deschapsia* and *Hordium jubatum*, have also produced flies, the first-named genus quite abundantly.

Of cultivated plants attacked, wheat and rye seem to be equally sought after, though the latter, owing to its stiffer straw, is more suitable to the larval development. Barley, owing to its quicker growth and the late date at which it is usually sown, escapes the main attack, as a rule, though it is by no means immune. Speltz is another suitable host; but oats, as in the case of the Hessian-fly, remain uninjured.

Among cultivated grasses, Western Rye grass (*A. tenerum*) now grown extensively in the Prairie Provinces for hay, sometimes harbours larvæ in moderate numbers, but up to the present it has fortunately proved less suitable than was feared, probably owing to its stems being more slender than the other wild species, which do not, therefore, allow the insect such free passage up and down.

Timothy has been found attacked on several occasions, once rather severely, but it does not seem to suffer as much as other grasses, besides which the infested plants often produce good seed, providing they are harvested before August 1.

Odd stems of *Festuca*, more particularly of the larger kinds, were found at Treesbank, Man., with larvæ in them. Couch grass, *Agropyron repens*, an imported weed, is a host plant of much importance.

METHODS OF CONTROL.

Ploughing.—All infested stubble should be ploughed down to a depth of not less than 5 inches between August 1 and June 1 of the following year. The soil should be thoroughly packed afterwards; this may result through the action of snows and rain in winter, but when the land is ploughed in spring time, it should be harrowed and then packed if possible. Loose shallow ploughing in springtime is practically useless as a check, the flies being easily able to make their way through the soil to the surface, but when carried out as recommended above, very few, if any, of the insects are able to escape. This has been demonstrated by a number of experiments.

Cutting Infested Grasses.—Grasses known to harbour, or suspected of harbouring larvæ should be cut with a mower between July 10 and August 1, but as soon as possible after the former date. By this means the larvæ will be caught in the stems before they are able to make their way to the lower portion of the plant beneath the ground, and as the grasses dry the grubs perish. Cutting grasses before that date would merely cause the flies to deposit their eggs elsewhere. This recommendation, however, does not refer to Redtop and its allies, nor to the Blue grasses, Brome grass or the smaller Fescues, which apparently are not attacked by the Sawfly.

Provided it is impossible to thoroughly plough fields as mentioned above, the farmer should take careful note of that portion of his crop worst affected; this will be next to last year's stubble, either his own or that of his neighbour. In this case, under ordinary conditions, the worst injury will extend into the fields for about one hundred feet, gradually getting less severe towards the centre. By ploughing down as much as possible of the worst infested portion between the dates mentioned above much future loss will be avoided.

A badly infested crop may sometimes be saved by harvesting it before the first of August, in other words, just before the Sawfly larvæ have had time to cut through the stems. While at this time it will not make first-class grain, nevertheless by this method the crop will be saved from becoming a total loss.

Burning stubble or straw piles to destroy this insect is of no practical value, as at the date when stubble can be burnt, larvæ are only to be found in that portion of the stem, located below the ground, being, therefore, out of reach by fire.